

Interdisciplinary Research and Training at the Geophysical Fluid Dynamics Program

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LONG-TERM GOALS

The long-term goals are to train new scientists to conduct research, and to enhance the abilities of experienced research workers in geophysical fluid dynamics. This field is fundamental to the field of numerical forecasting of ocean, atmosphere and environment.

OBJECTIVES

To help graduate students formulate and tackle innovative research problems in GFD. To promote an exchange of knowledge and ideas between investigators in the different scientific disciplines that deal with the dynamics of stratified fluids, rotating fluids, nonlinear waves, bio-fluid dynamic interactions, etc. To formulate tractable, important problems which are presently at the fringe of our understanding in the field of Geophysical Fluid Dynamics. To serve as a clearing-house for the mathematical, experimental and computational techniques which serve astrophysics, climate science, geodynamics, meteorology and oceanography.

APPROACH

We conduct a summer study school of ten weeks duration each summer. The participants are graduate student Fellows, visiting graduate students and visiting scientists. The first two weeks consist of ten principal lectures in the summer's topic conducted by an expert in that area. Lectures by associated participants follow at a rate of roughly one or two per day for the remaining weeks except for the last two weeks, when student Fellows are given time to complete and then present their results. About 10 graduate students are admitted as Fellows, selected from a pool of applicants from many disciplines who are in their second to fourth year of graduate school. Fellows receive a stipend for the full ten weeks. A Fellow conducts a research project under the guidance of the staff, provides a written project

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report, and orally present results in the tenth week. The Fellows also prepare note of the principal lectures. Several other graduate students visit for shorter periods to listen to lectures and interact with the staff. The faculty and staff (comprised of the faculty and the visiting scientists) are continually renewed throughout the summer, although there is a core group of faculty and several visitors (e.g. principal lectures) who remain for the entire summer. Most of these participants receive partial travel support from the program, but some participate for free. The lecture notes and the written report of the Fellows' projects are contained in a volume that is distributed is available on the GFD website and distributed in print form to certain organizations/individuals. Finally, a public lecture is presented each year on a topic of interest to the general public.

The program is governed and run by a faculty comprised of many leaders in their fields. The faculty are:

Neil Balmforth	Department of Mathematics, University of British Columbia
Oliver Buhler	Courant Institute, NYU
Claudia Cenedese	Woods Hole Oceanographic Institution
Eric Chassignet	RSMAS/MPO, University of Miami
Steve Childress,	Courant Institute, NYU
Charles Doering	Department of Mathematics, University of Michigan
Glenn Flierl	Department of Earth, Atmospheric and Planetary Sciences, MIT
Pascale Garaud	Department of Applied Mathematics and Statistics, University of California, Santa Cruz
Karl Helfrich	Woods Hole Oceanographic Institution
Louis Howard	MIT, Florida State University, and Duke University
Joseph B. Keller	Stanford University
Norm Lebovitz	Department of Mathematics, University of Chicago
Stephan Lewellyn-Smith,	Department of Mechanical and Aerospace Engineering &
	Scripps Institution of Oceanography, UCSD
Willem Malkus	Department of Mathematics, MIT
Philip Morrison	Physics Department, University of Texas at Austin
Antonello Provenzale	Istituto di Scienze dell'Atmosfera e del Clima, CNR Italy
Ed Spiegel	Astronomy Department, Columbia University
Melvin Stern	Department of Oceanography, Florida State University
Jean-Luc Thiffeault	Department of Mathematics, Imperial College, London
George Veronis	Department of Geology and Geophysics, Yale University
John Wettlaufer	Departments of Geology and Geophysics & Physics, Yale University
Jack Whitehead	Woods Hole Oceanographic Institution
William Young	Scripps Institution of Oceanography, UCSD

WORK COMPLETED

The subject of this year's principal lectures was "Nonlinear Waves." Roger Grimshaw (Loughborough University) and Harvey Segur (University of Colorado) shared the principal lecture duties. Nonlinear waves impact almost every branch of geophysical fluid dynamics, ranging from centimeter-scale gravity–capillary waves on the ocean surface to planetary waves in the atmosphere. The theory of nonlinear waves is a bedrock of classical applied mathematics, yet many of the recent advances and novel applications in this area have their roots in geophysical fluid dynamics. In addition to the principal lectures, talks by faculty and visitors covered numerous aspects of nonlinear waves and many other topics across the spectrum of geophysical fluid dynamics.

The names of the eleven 2009 Fellows, university affiliations, and titles of their projects were:

Michael Bates, University of South Wales, “Resonant triad interactions on an extended equatorial β -plane”

Erinna Chen, University of California, Santa Cruz, “Degradation of the internal tide over long bumpy topography”

Nicholas Grisouard, Université Joseph Fourier, Grenoble, “Quantum vortices in a glass of Bose-Einstein condensate”

Andong He, Penn State University, “Some geometrical aspects of nonlinear waves”

Yiping Ma, University of California, Berkeley, “The derivation and application of convective pattern equations”

Alireza Mashayekhi, University of Toronto, “Variation of the eddy diffusivity across jets in the southern ocean due to discontinuities”

Hélène Scolan, Ecole Normale Supérieure de Lyon, “Destabilizing a seiche with a movable dam”

Andrew Stewart, University of Oxford, “Nonlinear Rossby shelf waves in a rotating annulus”

Daisuke Takagi, University of Cambridge, “Nonlinear peristaltic waves”

Adrienne Traxler, University of California, Santa Cruz, “Transverse stability of Su-Gardner solutions”

Hiroki Yamamoto, Kyoto University, “Laboratory experiment on two coalescing axisymmetric turbulent plumes in a rotating fluid”

Finally, the GFD public lecture was held on August 6, 2009 and was attended by over 100 people. The lecturer was Professor Geoff Spedding, University of Southern California, who spoke on “Flight at Small Scales.”

RESULTS

The Principal Lectures and Fellows' reports are the tangible results. The 2009 program material will be finished in early 2010 and available as a technical report on the GFD website (<http://www.whoi.edu/page.do?pid=7937>) maintained at the Woods Hole Oceanographic Institution. A large number of published journal papers typically result from each summer program. This includes Fellows' reports that frequently become journal articles as well as papers that arise from interactions between the GFD Faculty and visitors.

IMPACT/APPLICATIONS

The GFD program advances discovery and understanding, while promoting teaching and training by involving graduate students in research. The research performed by the student Fellows at GFD sometimes provides the backbone of their doctoral theses. On other occasions, it introduces the Fellows to new problems in different areas, allowing them to broaden their research interests and acquire new tools from other disciplines to use in their own research. Above all, for many of the Fellows it provides the basic knowledge of how to conduct a research project and how to develop the work into a presentable, coherent form and into publishable scholarly articles. The opening lectures at GFD are meant to provide an introduction to a new field to both the students and experts from other disciplines, and seminars throughout the summer often have a pedagogical flavor.

By virtue of its very discursive and interactive style, GFD naturally promotes the dissemination of scientific results amongst researchers from very different backgrounds; techniques from different disciplines are readily transferred across disciplinary borders, and parallels between problems in very different fields can be easily appreciated. GFD also initiates discussion between leading experts as well as very inexperienced, beginning researchers, exposing all to current scientific ideas and technological understanding. Through the setting at the Woods Hole Oceanographic Institution, GFD brings university professors and students from a more academic background to this center of modern oceanography.

The staff pays close attention to each fellow and works to make each fellow achieve a good project in conjunction with a suitable advisor. The WHOI Academic Programs Office also has the Fellows evaluate the program, and the vast majority of comments are highly complementary.

We estimate that typically 20-50% of the student projects become included in their thesis or postdoctoral work and/or result in publications. The program does not follow the Fellows' research after the summer is finished although individual staff members often remain involved with the Fellows' continuation of their projects past the end of the summer.

REFERENCES

Various features of the program are contained on GFD website listed above. These includes a list of past Fellows, the titles of the lectures, a list of participating scientists, a yearly newsletter, and recent past volumes (containing lecture notes and the fellows' project reports).

PUBLICATIONS

Lecture notes and fellows reports are maintained on the GFD website.

HONORS

The founders of the GFD program (the original Steering Committee) received the American Geophysical Union "Excellence in Education Award" on May 29, 2008. The founders are Henry Stommel (dec.), Willem Malkus, George Veronis, Melvin Stern, Edward Spiegel, Joseph Keller and Louis Howard. This summer marked the 51st summer program.